Physiological response of aspen leaves to drought stress

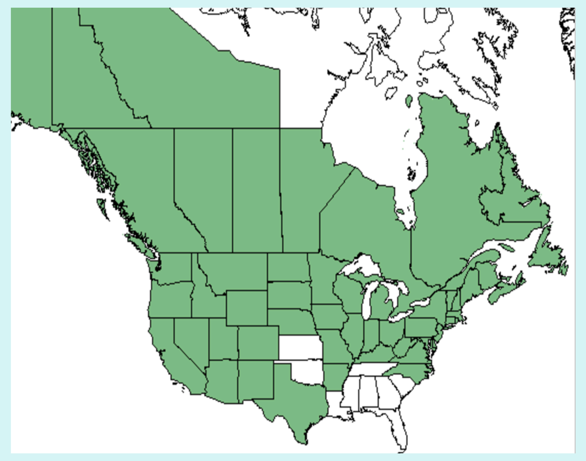
Isabella Armour, Nick Deacon, Jake Grossman, and Jeannine Cavender-Bares

Introduction

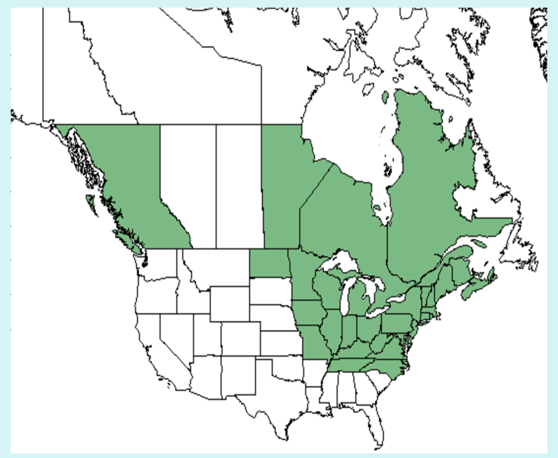
Drought stress tolerance plays a significant role in determining the distribution of vegetation on Earth, and with shifting patterns in rainfall and altered drought frequency expected over the course of the next fifty years, it is important that we develop a thorough understanding of how drought affects plants (1). Trees in particular provide necessary ecosystem services such as watershed protection, carbon storage, and wildlife habitat (2). The ability to predict their response to drought will allow for effective conservation and forestry in the face of a rapidly changing climate.

The genus *Populus* has been used as a model system for studying forest response to drought in the past (1, 2). It has been found that some plants, and more specifically, some *Populus* species, tolerate drought by upregulating the production of proteins and sugars in their tissues so as to increase the osmotic potential of their cells (3, 4). The research presented here focuses on two species from this genus, *P. tremuloides* and *P. grandidentata,* and the response of their leaf tissue to drought treatment. Experimental procedures for testing percent water loss, electrolyte leakage, and osmotic potential so as to quantify solute regulatory response mimic those of Pelah et al. 1997 and Wang et al. 1999.

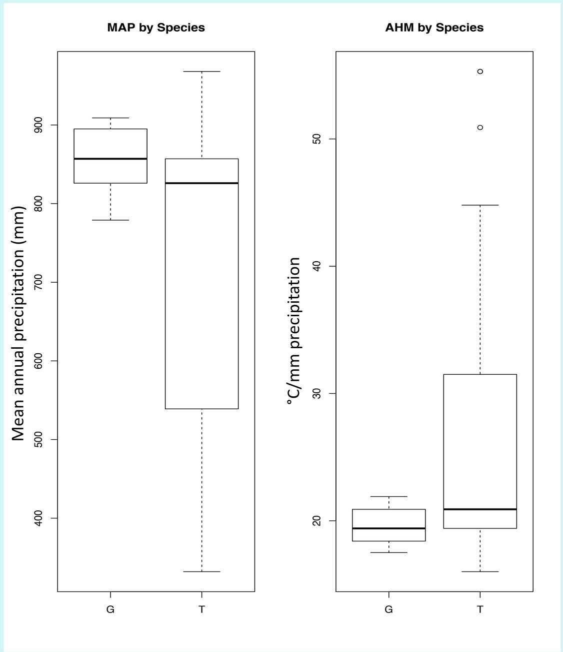
Hypotheses



P. tremuloides range



P. grandidentata range



Maps from the USDA Plant Database
Climatic variables plotted based on data from ClimateNA

P. tremuloides will be more tolerant of water stress because it has a broader range and inhabits the drier parts of that range when it overlaps with *P. grandidentata*, therefore:

- *P. tremuloides* leaves will have a **lower** percent water loss than *P. grandidentata*
- *P. tremuloides* leaves will have a **higher** amount of electrolyte leakage than *P. grandidentata*
- *P. tremuloides* leaves will have a **higher** osmotic potential than *P. grandidentata*

Results

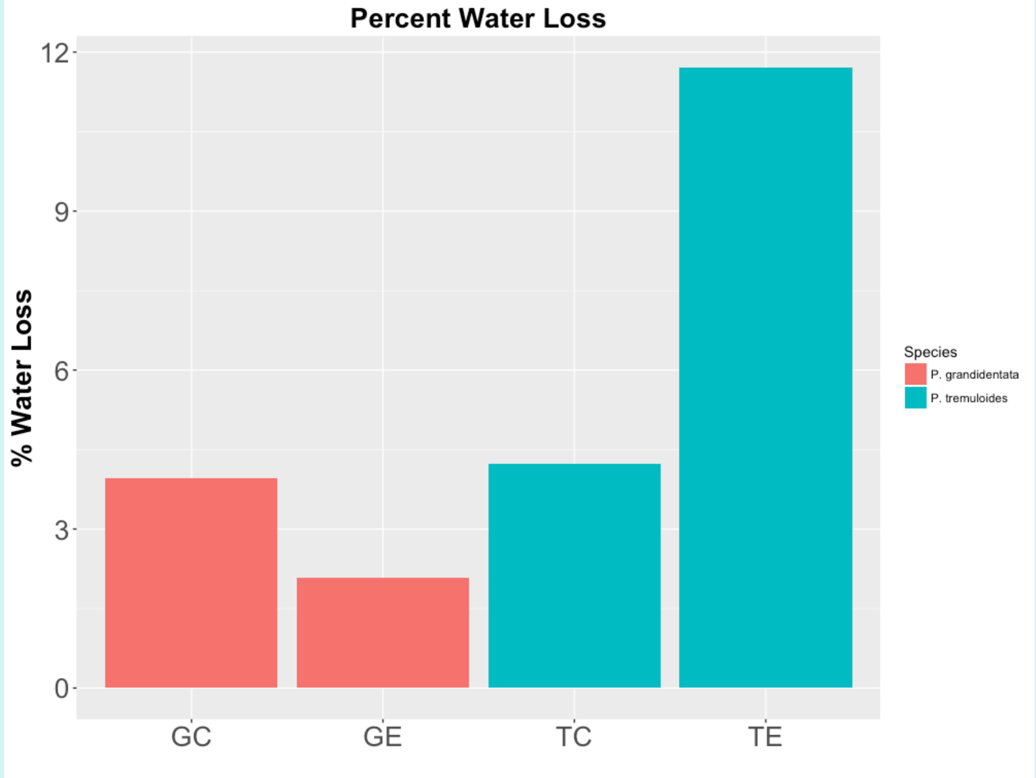
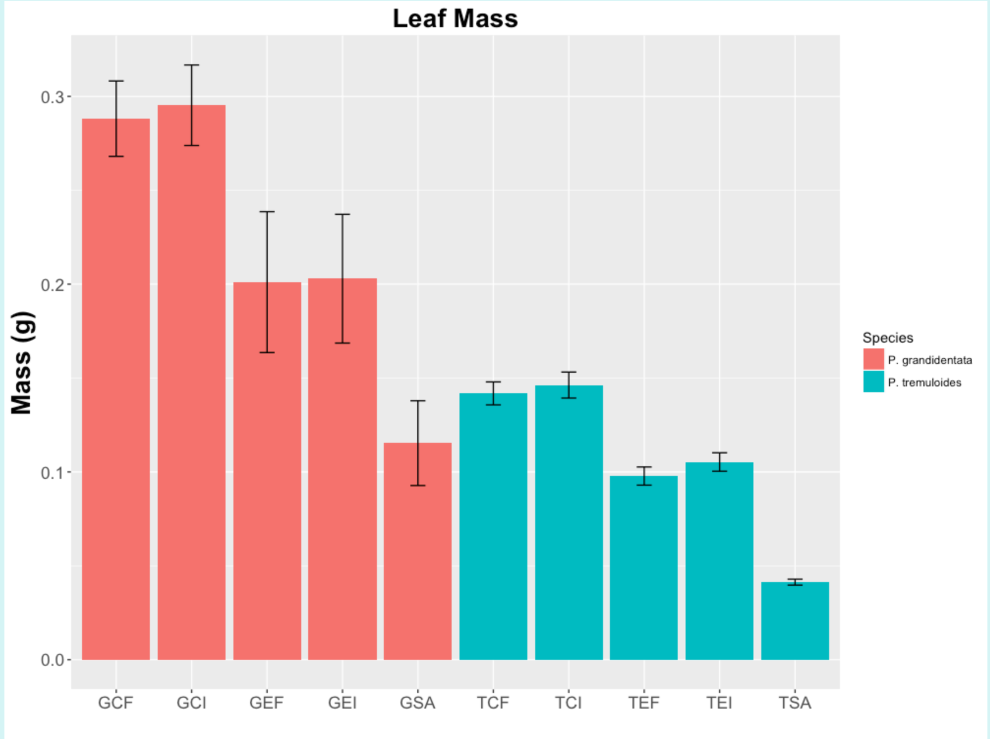


Figure 1. Percent water loss as a result of drying for both control and experimental treatments for both species. Percentages were obtained using this equation:

$$\%\ water\ loss = \frac{initial\ mass - final\ mass}{species\ average\ dry\ mass}$$

Figure 2. Average leaf masses for control and experimental leaves for both species before and after the 24-hour dry-down period.

<u>*Fig. 1 and 2 x-axis code:*</u>
G = P. grandidentata
T = P. tremuloides
C = control
E = experimental
I = initial, pre-dry-down
F = final, post-dry-down
G/TSA = average dry mass for each species



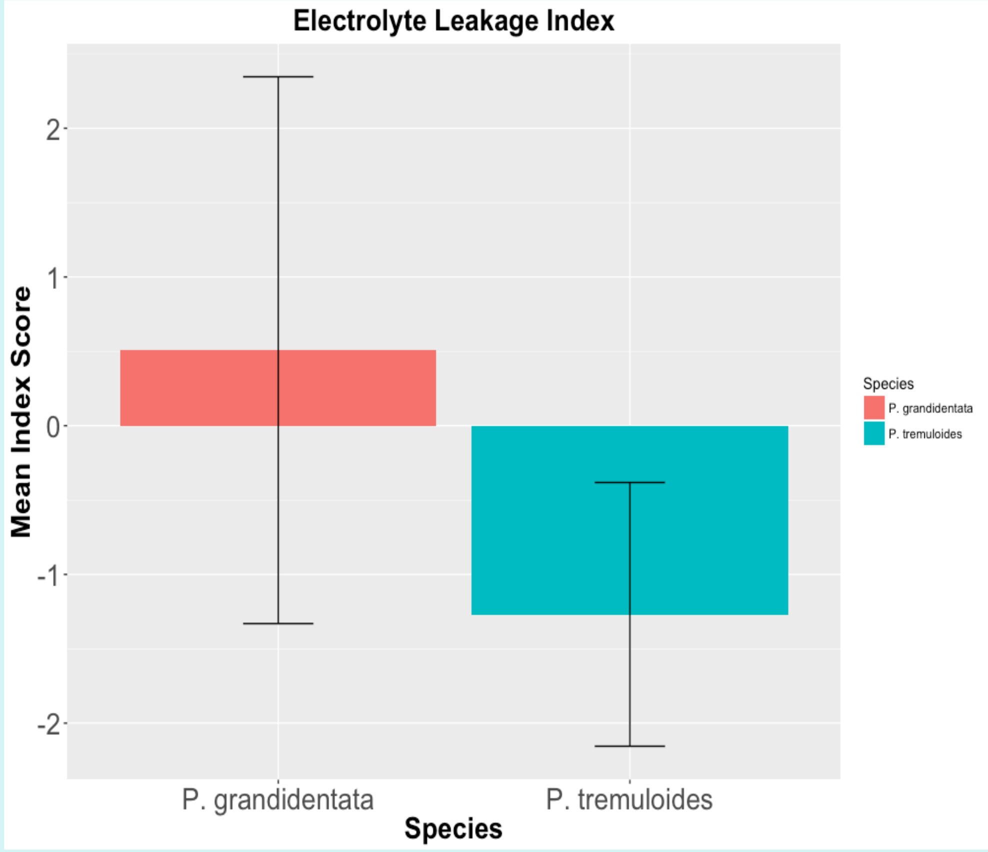
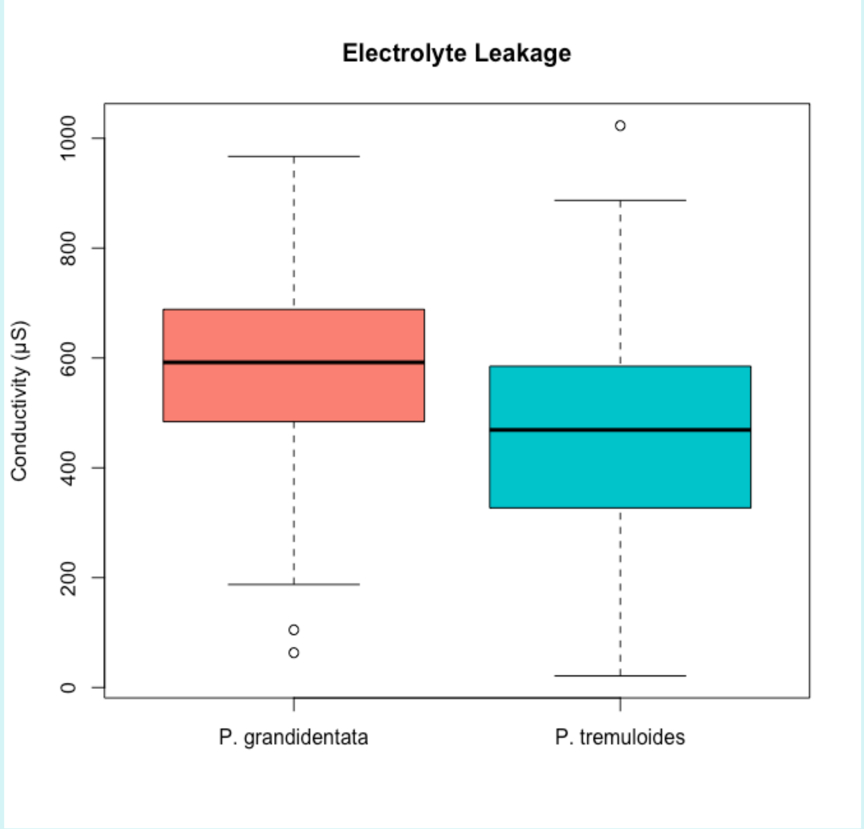


Figure 3. Average electrolyte leakage index scores for both species. A negative value indicates the experimental treatment was more damaged than the control. A positive value indicates the opposite. Values were obtained using this equation:

$$score = \left[\left(\frac{experimental\ initial}{experimental\ boiled}\right) - \left(\frac{control\ initial}{control\ boiled}\right)\right] * 100$$

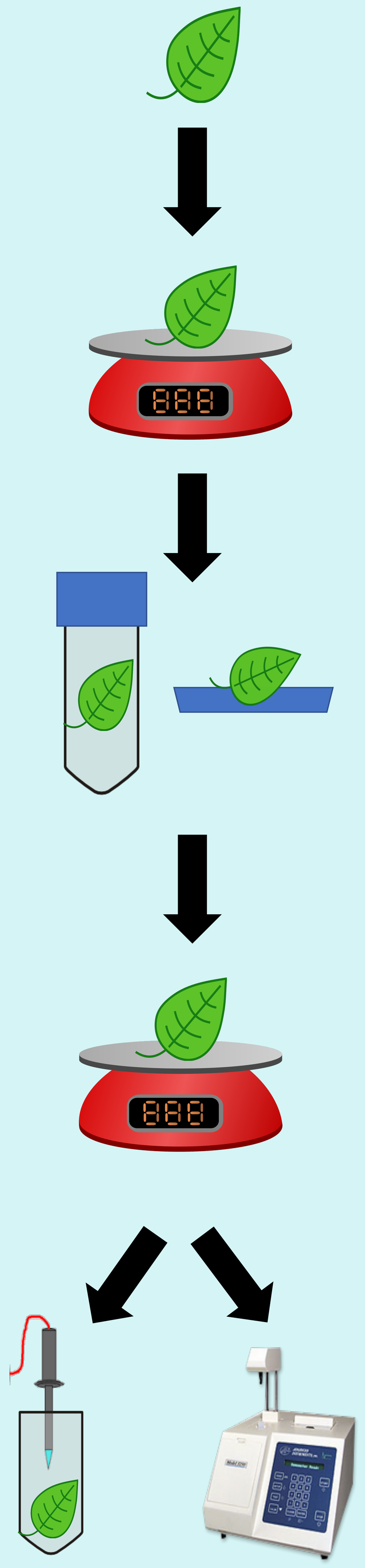
Figure 4. P. grandidentata has a mean conductivity of 560.99 µS, and a range of 903.7 µS. *P. tremuloides* has a mean conductivity of 451.35 µS and a range of 1001.9 µS.



References
1. P. Nilsson *et al.*, The genetics and genomics of the drought response in Populus. *Plant J.* **48**, 321–341 (2006).
2. H. D. Bradshaw, R. Ceulemans, J. Davis, R. Stettler, Emerging Model Systems in Plant Biology : Poplar (Populus) as a Model Forest Tree. *J. Plant Growth Regul.*, 306–313 (2000).
3. D. Pelah, W. Wang, A. Altman, O. Shoseyov, D. Bartels, Differential accumulation of water stress-related proteins , sucrose synthase and soluble sugars in Populus species that differ in their water stress response. *Physiol. Plant.* **99**, 153–159 (1997).
4. W. X. Wang, T. Tzfira, N. Levin, O. Shoseyov, A. Altman, Plant tolerance to water and salt stress: The expression pattern of a water stress responsive protein (BspA) in Transgenic Aspen plants. *Plant Biotechnol. Vitr. Biol. 21st Century*, 561–565 (1999).

Methods

1. Leaves were removed from saplings growing in a common garden at Cedar Creek Ecosystem Science Reserve and weighed.
2. Control leaves were placed in humidified tubes, while experimental leaves were placed in weigh boats and subjected to a 24-hour dry-down treatment.
3. Both control and experimental leaves were weighed after the 24-hour period.
4. Leaves from both treatment groups were placed in tubes with 9mL of deionized water and allowed to sit for 15 minutes. The conductivity of the leaf-water solution was recorded once after the 15 minute period and again after the tubes had been autoclaved.
5. Hole punches were taken from leaves from both treatment groups and used for osmometry measurements to determine the solute concentration in the leaf tissue.



Conclusions

<u>Percent water loss</u>

- Treatment groups were biased by mass. Control leaves were consistently larger than experimental leaves.
- The order in which samples were processed may have affected initial mass measurements.
- Bias makes using species average dry mass problematic.

<u>Electrolyte leakage</u>

- No evidence for intracellular cell damage from drying. Cells were shriveling up, but not bursting which is why we don't see differences in leakage.
- *P. tremuloides* has a broader range of electrolyte leakage, potentially meaning that it is more plastic in its response to water stress than *P. grandidentata*.

<u>Osmotic potential</u>

- Leaf disks were extremely dry upon measurement, so dry that the osmometer could not get readings from any of the experimental discs and could only get readings from 30% of the control discs.